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Sleep and Modeled Performance of Arctic Patrollers during Operation Nunalivut 2010

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Defence R&D Canada
Technical Memorandum
DRDC Toronto TM 2011-037
July 2011

Canada

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In conducting the research described in this report, the investigators adhered to the policies and procedures set out in the Tri-Council Policy Statement: Ethical conduct for research involving humans, National Council on Ethics in Human Research, Ottawa, 1998 as issued jointly by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

Abstract

Background: The goal of this work was to monitor sleep (via wrist actigraphs) in Arctic patrollers and generate cognitive effectiveness models for each patroller using a program called Fatigue Avoidance Scheduling Tool (FAST^{TM}). **Methods:** Actigraphic data were collected from 23 Arctic patrollers of whom 3 were Inuit Rangers (who ranged from 25 to 62 years of age), from one ranger instructor (48 years of age) and from 19 troops who were freshly deployed from various regions across southern Canada (who ranged from 21 to 54 years of age). The patrols ranged from 5 to 14 days in duration. Sleep data were recorded for several days at Canadian Forces Station Alert prior to departing on patrol and throughout the patrols. The following sleep parameters (primary sleep period minutes, total daily sleep minutes, number of daily naps, daily nap minutes, sleep latency in minutes, number of sleep episodes in the primary sleep period, and WASO (Wake After Sleep Onset) in minutes) were recorded and graphed for each day as well as averaged over 16 days. Total daily sleep minutes along with daily work periods were inputted to FAST^{TM} to generate models of cognitive effectiveness for each of the 23 Arctic patrollers. **Results and Discussion:** Inuit Rangers obtained more sleep in their primary sleep periods, have fewer sleep episodes and have less wake time within their primary sleep periods than their freshly deployed counterparts. On several days the FAST^{TM} models for 2 of the 3 Inuit Rangers predicted levels of performance equivalent to a blood alcohol content of 0.05%. The FAST^{TM} models for 14 freshly deployed soldiers predicted more work periods spent at 0.05% and at 0.08% blood alcohol content than their Inuit Ranger counterparts. **Conclusions:** All Arctic patrollers require sufficient sleep to avoid impaired performance. Planners who set the Operational Tempo for Arctic exercises should understand the impact that insufficient sleep can have on operational readiness, and plan accordingly, to the extent possible.

Résumé

Contexte : Les présents travaux visaient à surveiller le sommeil (à l’aide de bracelets actigraphes) chez des patrouilleurs de l’Arctique et à produire des modèles de l’efficacité cognitive pour chaque patrouilleur en utilisant un programme appelé Fatigue Avoidance Scheduling Tool (FAST^{TM}). **Méthodes :** Les données actigraphiques de 23 patrouilleurs de l’Arctique, qui comprenaient 3 Rangers inuits (âgés de 25 à 62 ans), un instructeur ranger (âgé de 48 ans) et 19 soldats (âgés de 21 à 54 ans) nouvellement déployés depuis diverses régions dans le sud du Canada, ont été recueillies. Les patrouilles se sont échelonnées sur une période 5 à 14 jours. Les données sur le sommeil ont été consignées pendant plusieurs jours à la station des Forces canadiennes Alerte avant le départ pour la patrouille et pendant les patrouilles. Les paramètres suivants sur le sommeil ont été consignés et reproduits sous forme de graphiques pour chaque journée, et les moyennes ont été établies sur 16 jours : principales périodes de sommeil en minutes, durée totale du sommeil quotidien en minutes, nombre de siestes quotidiennes, durée des siestes quotidiennes en minutes, latence du sommeil en minutes, nombre d’épisodes de sommeil dans la principale période de sommeil et temps d’éveil en minutes. La durée totale de sommeil quotidien en minutes ainsi que les périodes de travail quotidiennes ont été saisies dans le logiciel FAST^{TM} afin de produire des modèles de l’efficacité cognitive pour chacun des 23 patrouilleurs de l’Arctique. **Résultats et analyses :** Les Rangers inuits ont dormi davantage dans leurs

principales périodes de sommeil, ils avaient moins d’épisodes de sommeil et un temps d’éveil moindre dans leurs principales périodes de sommeil que leurs vis-à-vis nouvellement déployés. Sur plusieurs jours, les modèles FAST™ pour 2 des 3 Rangers inuits prédisent des niveaux de rendement équivalent à un taux d’alcoolémie de 0,05 %. Les modèles FAST™ pour 14 soldats nouvellement déployés prédisent davantage de périodes de travail effectuées avec un taux d’alcoolémie de 0,05 % et de 0,08 % que leurs vis-à-vis Rangers inuits. **Conclusions :** Tous les patrouilleurs de l’Arctique doivent dormir suffisamment pour éviter une baisse de rendement. Les planificateurs qui établissent le rythme opérationnel pour les exercices dans l’Arctique doivent comprendre les répercussions du manque de sommeil sur l’état de préparation opérationnelle et planifier en conséquence, dans la mesure du possible.

Executive summary

Sleep and Modeled Performance of Arctic Patrollers during Operation Nunalivut 2010:

Michel A. Paul; Fethi Bouak; DRDC Toronto TR 2011-037; Defence R&D Canada – Toronto; July 2011.

Introduction: The goal of this work was to monitor sleep (via wrist actigraphs) in Arctic patrollers and generate cognitive effectiveness models for each patroller using a program called Fatigue Avoidance Scheduling Tool (FAST^{TM}). Actigraphic data were collected from 23 Arctic patrollers of whom 3 were Inuit Rangers, one was a Ranger instructor and 19 were troops freshly deployed from various regions across southern Canada. The patrols ranged from 5 to 14 days in duration. Sleep data were recorded for several days at Canadian Forces Station Alert prior to departing on patrol and throughout the patrols.

Results: Inuit Rangers obtained more sleep in their primary sleep periods, have fewer sleep episodes and have less wake time within their primary sleep periods than their freshly deployed counterparts. On several days, the FAST^{TM} models for 2 of the 3 Inuit Rangers predicted levels of performance equivalent to a blood alcohol content of 0.05%. The FAST^{TM} models for 14 freshly deployed soldiers predicted more work periods spent at 0.05% and at 0.08% blood alcohol content than their Inuit Ranger counterparts.

Significance: All Arctic patrollers require sufficient sleep to avoid impaired performance. In some cases, the Operational Tempo of Arctic Exercises may preclude sufficient sleep.

Future plans: Planners who set the Operational Tempo for Arctic exercises should understand the impact that insufficient sleep can have on operational readiness, and plan accordingly, to the extent possible. To improve Arctic operational readiness, it is highly desirable that defence scientists be invited to participate in the planning stages for all Arctic operations. This will allow the Canadian Forces to exploit scientific opportunities for improvement of Arctic operational readiness.

Sommaire

Modélisation du rendement des patrouilleurs de l'Arctique pendant l'opération Nunalivut 2010 :

Michel A. Paul; Fethi Bouak; DRDC Toronto TR 2011-037; R & D pour la défense Canada – Toronto; Juillet 2011.

Introduction ou contexte: Les présents travaux visaient à surveiller le sommeil (à l'aide de bracelets actigraphes) chez des patrouilleurs de l'Arctique et à produire des modèles de l'efficacité cognitive pour chaque patrouilleur en utilisant un programme appelé Fatigue Avoidance Scheduling Tool (FAST^{TM}). Les données actigraphiques de 23 patrouilleurs de l'Arctique, qui comprenaient 3 Rangers inuits, un instructeur ranger et 19 soldats nouvellement déployés depuis diverses régions dans le sud du Canada, ont été recueillies. Les patrouilles se sont échelonnées sur une période de 5 à 14 jours. Les données sur le sommeil ont été consignées pendant plusieurs jours à la station des Forces canadiennes Alerte avant le départ pour la patrouille et pendant les patrouilles.

Résultats: Les Rangers inuits ont dormi davantage dans leurs principales périodes de sommeil, ils avaient moins d'épisodes de sommeil et un temps d'éveil moindre dans leurs principales périodes de sommeil que leurs vis-à-vis nouvellement déployés. Sur plusieurs jours, les modèles FAST^{TM} pour 2 des 3 Rangers inuits prédisent des niveaux de rendement équivalent à un taux d'alcoolémie de 0,05 %. Les modèles FAST^{TM} pour 14 soldats nouvellement déployés prédisent davantage de périodes de travail effectuées avec un taux d'alcoolémie de 0,05 % et de 0,08 % que leurs vis-à-vis Rangers inuits.

Importance: Tous les patrouilleurs de l'Arctique doivent dormir suffisamment pour éviter une baisse de rendement. Dans certains cas, le rythme opérationnel pour les exercices dans l'Arctique peut prévenir le manque de sommeil chez les patrouilleurs.

Perspectives: Les planificateurs qui établissent le rythme opérationnel pour les exercices dans l'Arctique doivent comprendre les répercussions du manque de sommeil sur l'état de préparation opérationnelle et planifier en conséquence, dans la mesure du possible. Afin d'améliorer l'état de préparation opérationnelle dans l'Arctique, il est fortement souhaitable que les scientifiques du MDN soient invités à participer aux phases de planification de toutes les opérations dans l'Arctique. Cela permettra aux FC d'exploiter les occasions scientifiques d'améliorer l'état de préparation opérationnelle dans l'Arctique.

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1 Background

During the planning for the Exercise Operation (Op) Nunalivut 2010, funding for the Arctic chronobiology project (14dm04) was not yet in place. However, since this Exercise occurs only once a year, we decided to attempt a data collection during Op Nunalivut 2010 despite the fact that we would not be able to provide stress allowance to any Arctic patrollers who volunteered to act as participants in this data collection. Op Nunalivut 2010 was based out of Canadian Forces Station (CFS) Alert during the month of April and involved either continuously roving patrols or patrol to a location (Ward Hunt Island, approximately 100 nautical miles west of CFS Alert) from which short daily patrols occurred.

The goal of this data collection was to monitor sleep (via wrist actigraphs) in Arctic patrollers and input the wrist actigraphically-derived sleep data in a cognitive effectiveness modeling program called FAST ™ (Fatigue Avoidance Scheduling Tool) to determine the modeled performance of the Arctic patrollers who participated in this data collection. We have used FAST ™ many times to measure cognitive effectiveness in Canadian Forces (CF) operations [1-7], and expect to use FAST™ to model performance of sailors (on the frigate Her Majesty's Canadian Ship (HMCS) St John's) during Op Nanook, 2011.

2 Methods

2.1 Arctic patroller participants

A total of 27 participants agreed to wear a wrist actigraph (to measure their daily sleep) during Op Nunalivut and to maintain daily entries into a sleep log to protect against actigraph failure. An actigraph is a small accelerometer about the size of a wrist watch and is worn on the wrist. Based on a reduction algorithm, an actigraph provides a motion-based estimate of daily sleep quantitatively to the nearest minutes for weeks at a time.

Of the 27 patrollers, 4 were native Inuit, 1 was a CF Ranger instructor who had been in the Arctic for at least one year, and 22 were soldiers freshly deployed to the Arctic (mainly reservists, but also 2 regular force Search and Rescue Technicians (SAR Techs)) from various bases across Canada.

Of the 4 native Inuit patrollers, 1 removed his actigraph after 2 days. One of the freshly deployed soldiers wore his actigraph intermittently over several days and then stopped wearing it altogether. The actigraph of another freshly deployed soldier failed to function. What little data are available from these 4 individuals is not part of this report. The remaining 23 participants are split across the 3 subject types as follows: 3 Inuit Rangers, 1 Ranger Instructor, and 19 personnel freshly deployed from various bases across Canada.

2.1.1 Patroller age demographics

The 3 Inuit Rangers who completed the data collection ranged from 25 to 62 years of age and mean ± standard deviation was 45.3 ± 18.7 years of age.

The Ranger instructor who participated was 48 years of age. Of the 19 freshly deployed soldiers, one declined to provide us his age and another soldier could not be reached for his date of birth. The remaining 17 freshly deployed soldiers whose ages we could obtain, ranged from 21 to 54 years of age with a mean age ± standard deviation 28.9 ± 8.6 years.

2.1.2 Number of days on patrol

Of the 3 Inuit Rangers, 2 were on patrol for 11 days and the other for 12 days. The Ranger Instructor was on patrol for 14 days. Of the freshly deployed soldiers, 1 was on patrol for 5 days, 4 were on patrol for 6 days, 3 were on patrol for 7 days, one was on patrol for 10 days, one was on patrol for 11 days, 7 were on patrol for 12 days, one was on patrol for 13 days and one soldier remained at CFS Alert without going on patrol.

2.2 FAST ™ modeling program

The wrist actigraphically-derived sleep data were used as inputs into a cognitive effectiveness modeling program called Fatigue Avoidance Scheduling Tool (FAST)™ to develop models of cognitive performance for each of the 23 participants.

A description of FAST™ is provided in **Annex A**. Some details regarding the graphs of these models are as follows:

- The vertical axis on the left side of the FAST™ graphs represents human cognitive performance effectiveness as a percentage of optimal performance (100%). Effectiveness has a range from 100 (normal best) to 0 (worst case). The oscillating line in the diagram represents average performance (cognitive effectiveness) as determined by time of day, biological rhythms, time spent awake, and amount of sleep.
- The dotted line which is below the cognitive effectiveness curve and follows a similar oscillating pattern as the cognitive effectiveness curve represents the 10th percentile of cognitive effectiveness.
- The green band (from 90% to 100%) represents acceptable cognitive performance effectiveness for workers conducting safety sensitive jobs (flying, driving, weapons operation, command and control, etc.).
- The yellow performance band (from 65% to 90% cognitive effectiveness) indicates caution. Personnel engaged in skilled performance activities such as aviation should not be allowed to operate within this performance band.
- The area from the dotted line to the pink area represents the cognitive effectiveness equivalent to the circadian nadir and a second day without sleep.
- The pink performance band (below 65%) represents performance effectiveness after 2 days and a night of sleep deprivation. Under these conditions, no one can be expected to function well on any task.
- A value of 77% cognitive effectiveness corresponds to a blood alcohol content (BAC) of 0.05% (legally impaired in some jurisdictions). A value of 70% cognitive effectiveness corresponds to a BAC of 0.08% (legally impaired in most jurisdictions). These BAC equivalency levels associated with sleep deprivation/fatigue are based on three important studies [8-10].
- The abscissa (x-axis) illustrates periods of work (red bars), sleep (blue bars), darkness (gray bars) and time of day in hours.
- The red triangles labelled C1 located just above the abscissa are event markers indicating when each patroller departed from CFS Alert on Arctic Patrol.

3 Results

3.1 Wrist actigraphically-measured sleep

The sleep data for each of the three types of subjects (Inuit Rangers, Ranger Instructor, and soldiers freshly deployed to the high Arctic are represented in the following three subsections. Because of the different numbers of subjects across the 3 subject groups, we cannot perform detailed statistical analysis to clarify differences between subject groups. However, we illustrate daily sleep behaviour over 16 days for each group and we collapse the data over days to calculate the average daily sleep behaviours across groups for the following parameters; total sleep minutes for the primary daily sleep period, total daily sleep minutes including naps, number of naps per day, number of sleep episodes within the primary daily sleep period, "sleep latency" (i.e., the number of minutes to fall asleep after retiring to bed) for the primary daily sleep period, and WASO (i.e., wake after sleep onset for the daily primary sleep period). These results are shown graphically in *Figures 1* to *14.*

3.1.1 Graphs of sleep parameters over 16 days

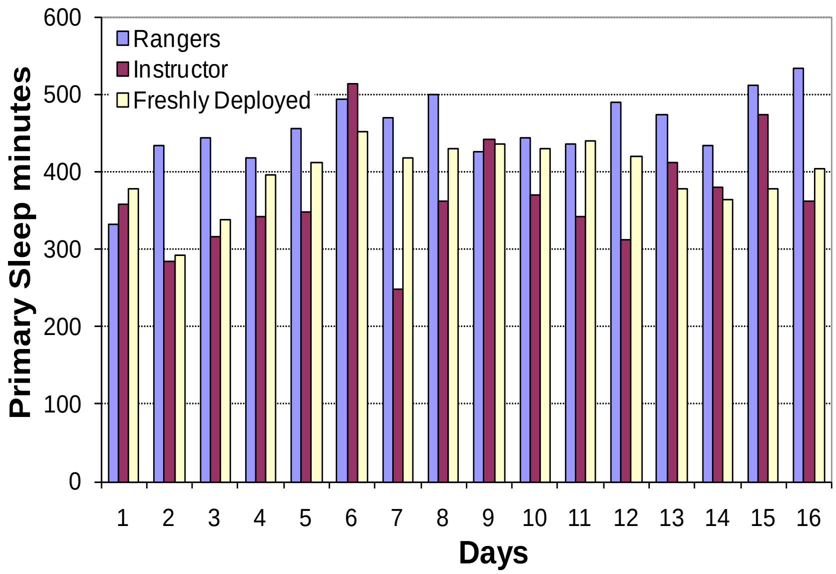

Figure 1: Average sleep minutes during main daily sleep period over 16 days across Rangers, Instructor, and freshly deployed soldiers). On Days 9, 10, and 11, all three subject types appear to obtain similar sleep patterns during the main sleep period. However, during other days, differences in sleep minutes are evident between the three subject types.

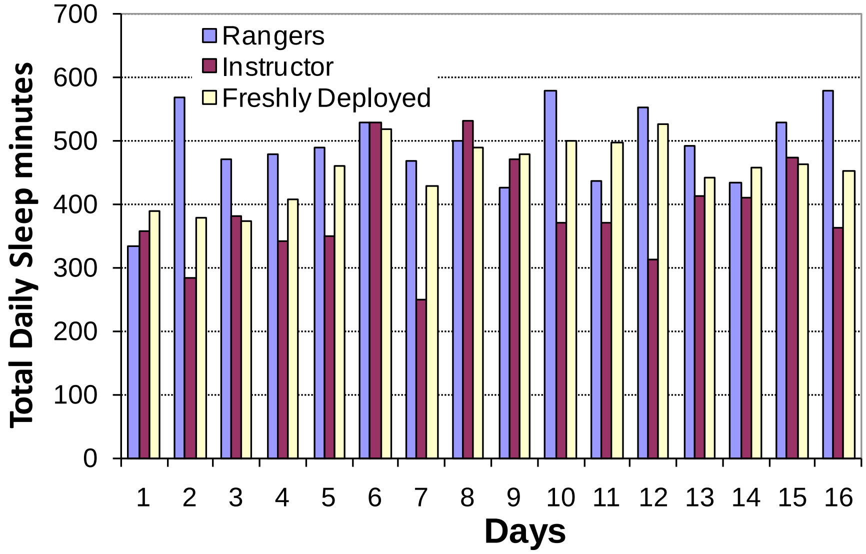

Figure 2: Average total daily sleep (i.e., main sleep period + naps) over 16 days across the 3 subject types. On Day 8, all subjects obtain similar total sleep. Otherwise, there are differences across the subject types (Rangers, Instructor and freshly deployed soldiers).

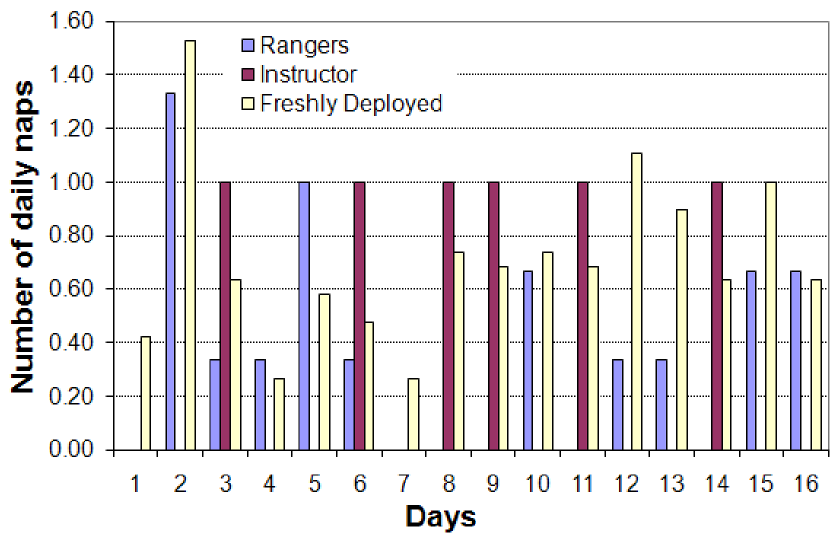

Figure 3: Average number of daily naps over 16 days across the 3 subject types. On Days 1 and 7, only the freshly deployed soldiers napped. On Days 2, 3, 6 and 13, all subjects napped.

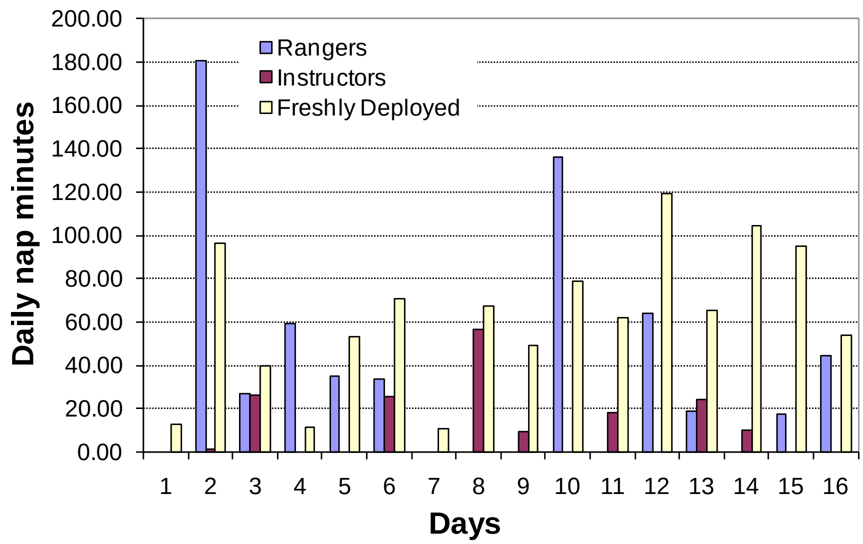

Figure 4: Average number of daily nap minutes over 16 days across the 3 subject types. On Days 1 and 7, only the freshly deployed soldiers napped. On Days 2, 3, 6 and 13, all subjects napped.

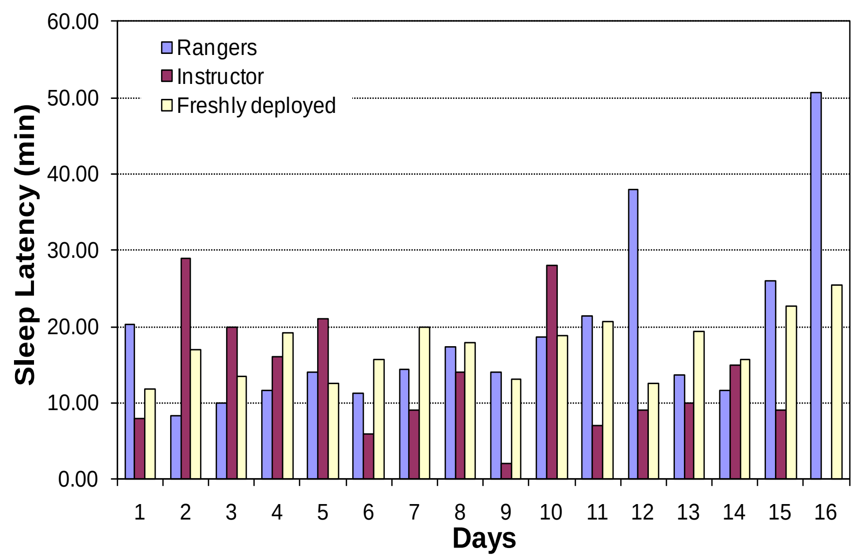

Figure 5: Average sleep latency (i.e., number of minutes to fall asleep after retiring to bed) over 16 days across the 3 subject types.

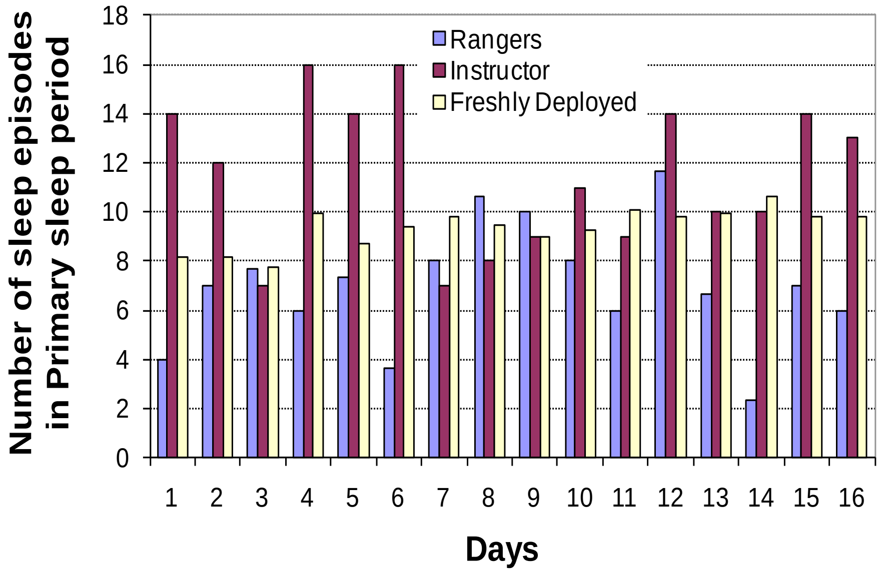

Figure 6: Average number of sleep episodes in primary sleep period over 16 days across the 3 subject types.

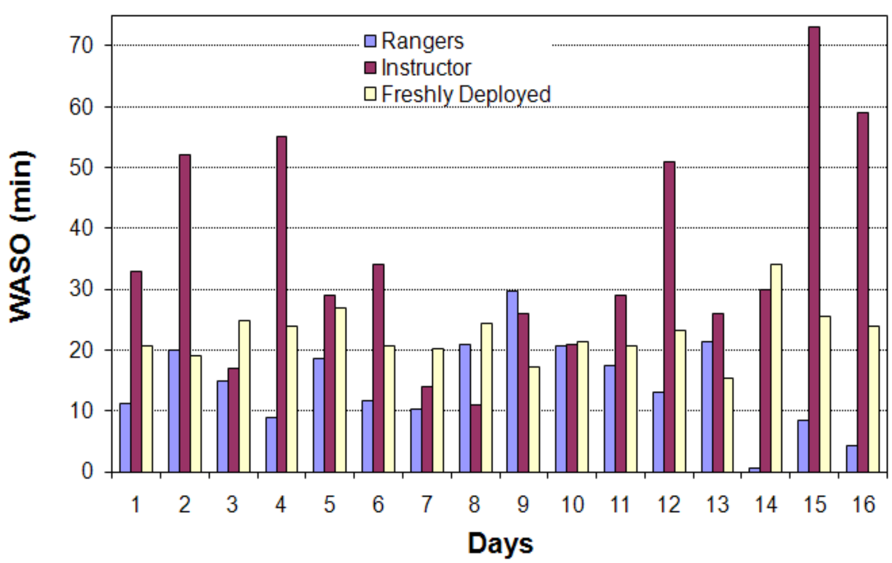

Figure 7: Average WASO (Wake After Sleep Onset) over 16 days across the 3 subject types.

3.1.2 Graphs of daily sleep parameters averaged over 16 days

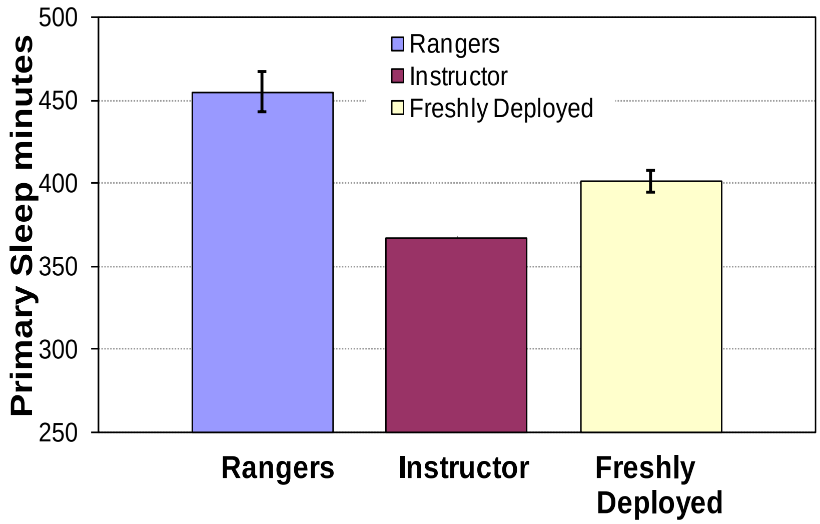

Figure 8: Average primary sleep minutes during main daily sleep period across Rangers, Instructor, and freshly deployed soldiers.

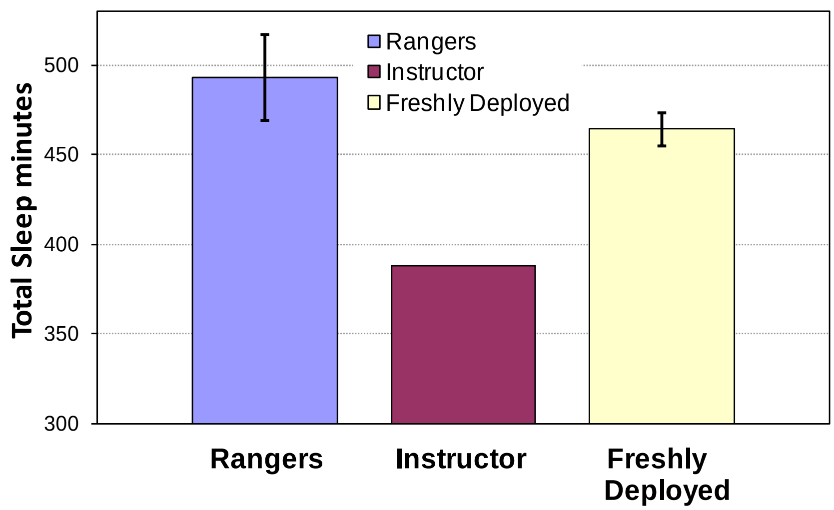

Figure 9: Average total daily sleep minutes (i.e, primary sleep plus naps) across Rangers, Instructor, and freshly deployed soldiers.

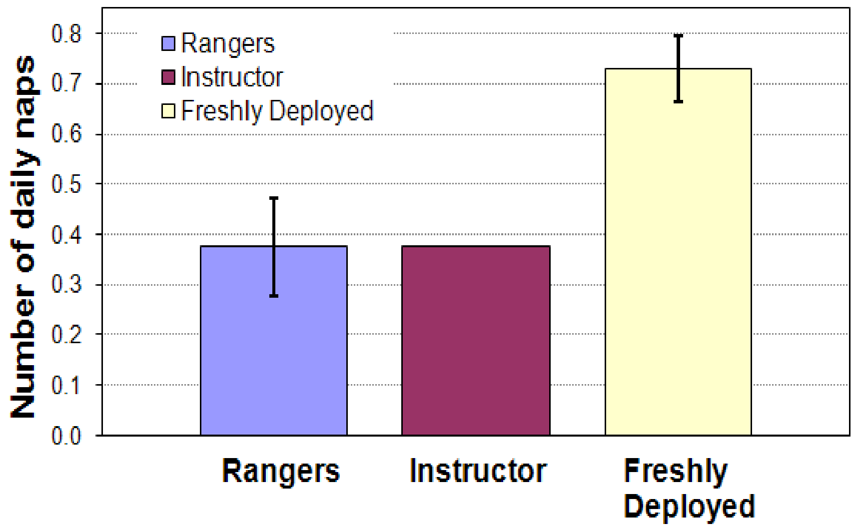

Figure 10: Average total number of daily naps across Rangers, Instructor, and freshly deployed soldiers.

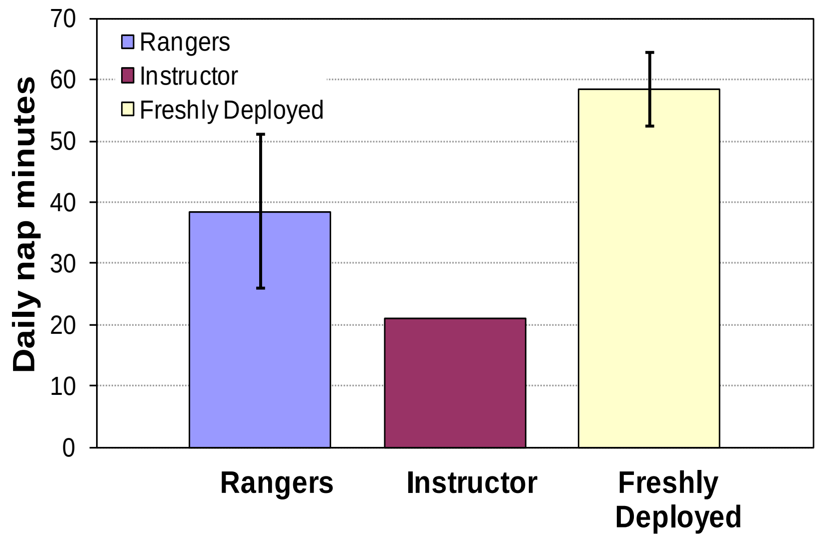

Figure 11: Average total daily nap minutes across Rangers, Instructor, and freshly deployed soldiers.

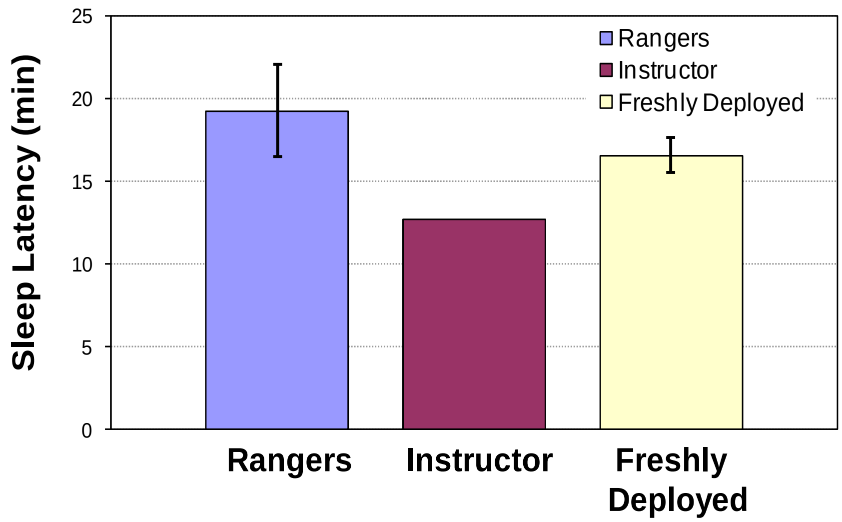

Figure 12: Average total daily sleep latency (i.e., number of minutes to fall asleep after retiring to bed) across Rangers, Instructor, and freshly deployed soldiers.

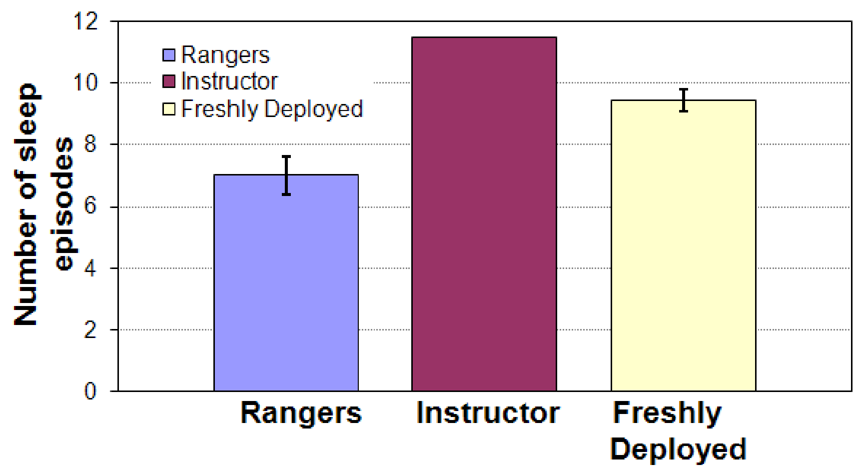

Figure 13: Average total daily number of sleep episodes across Rangers, Instructor, and freshly deployed soldiers.

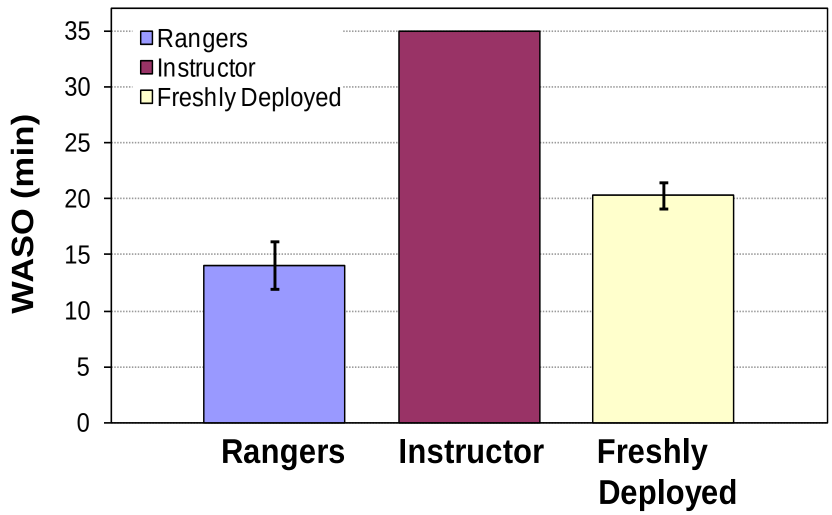

Figure 14: Average total daily WASO across Rangers, Instructor, and freshly deployed soldiers.

3.2 Modeled Cognitive Performance with FAST™

The sleep data for each of the three types of subjects, along with their work periods are the two data streams inputted to FAST ™. Because we did not have access to the subjects either during or after Op Nunalivut we do not have their exact daily work periods. However, we decided to commence all work periods one hour after awakening from the daily primary sleep period, and end all work periods one hour before commencing the daily primary sleep period. We also commenced work periods 30 minutes after awakening from any nap and ended work periods 30 minutes before any nap. A follow-up conversation with a Ranger Instructor confirmed that our decisions around primary sleep and naps for “work-start” and “work-end” were appropriate.

The red triangle marked as C1 on the x-axis of the FAST ™ models in *Figures 15* to *37* represents the date and time that each subject left CFS Alert for patrol duties.

3.2.1 Modeled performance of each of the 3 High Arctic Ranger subjects

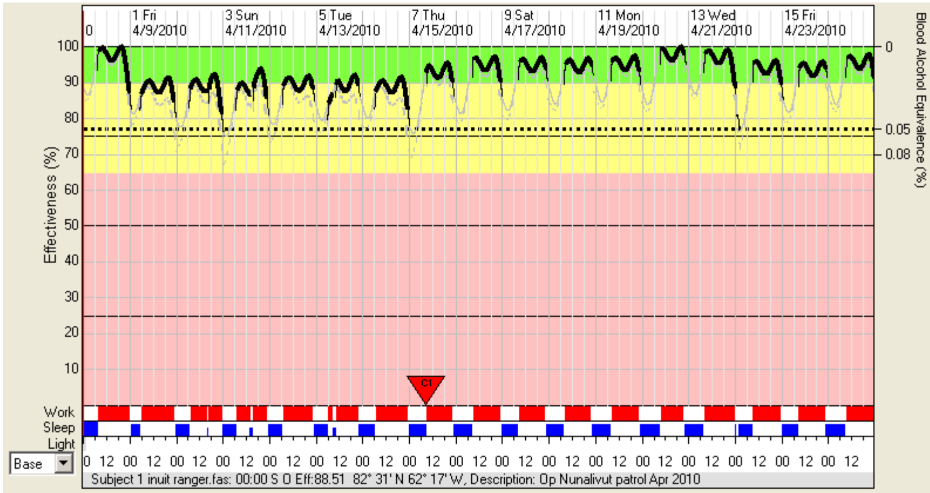

Figure 15: This Ranger (Subject 1) had better sleep hygiene and therefore better modeled performance after leaving CFS Alert for patrol duties relative to before patrol in CFS Alert. He averaged 7 hours and 57 minutes of sleep per day. His mean cognitive effectiveness during work ranged from 85.8% to 98.2% and averaged 93.4%.

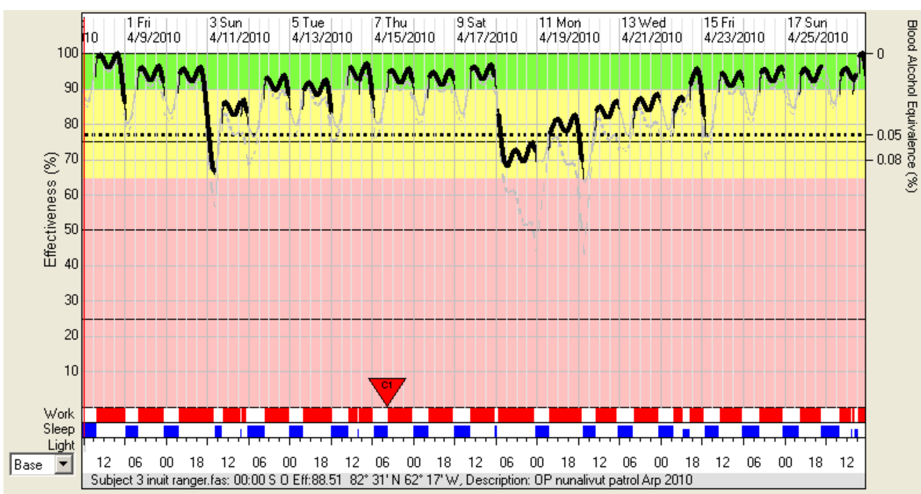

Figure 16: This Ranger (Subject 3) averaged 7 hours and 47 minutes of sleep per day. His mean cognitive effectiveness during work ranged from 72.0 % to 98.5% and averaged 89.6%. However, 4 days into his patrol, his work performance reached a nadir of about 68% (BAC higher than 0.08%), and he spent 95% of his work time on that day below criterion for blood alcohol equivalent to 0.05%.

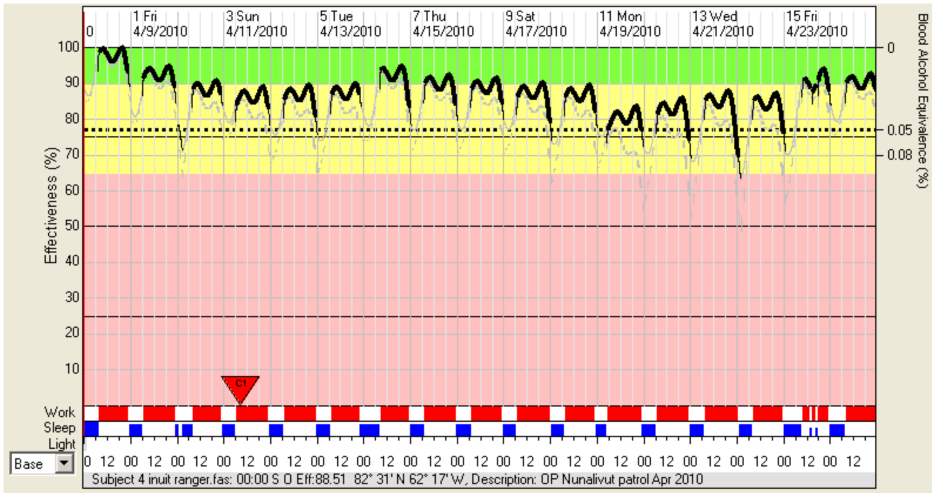

Figure 17: This Ranger (Subject 4) averaged 6 hours and 47 minutes of sleep per day. His mean cognitive effectiveness during work ranged from 80.9 % to 98.2% and averaged 88.2%. In the three days at CFS Alert prior to patrol duties, he shows a linearly decreasing pattern of daily sleep and performance, then sleep and performance slowly recovers over the next 3 days. Performance started to fall again over the next 5 days and slowly recovered over the subsequent 5 days, all due to changes in sleep hygiene.

3.2.2 Modeled performance of the Instructor

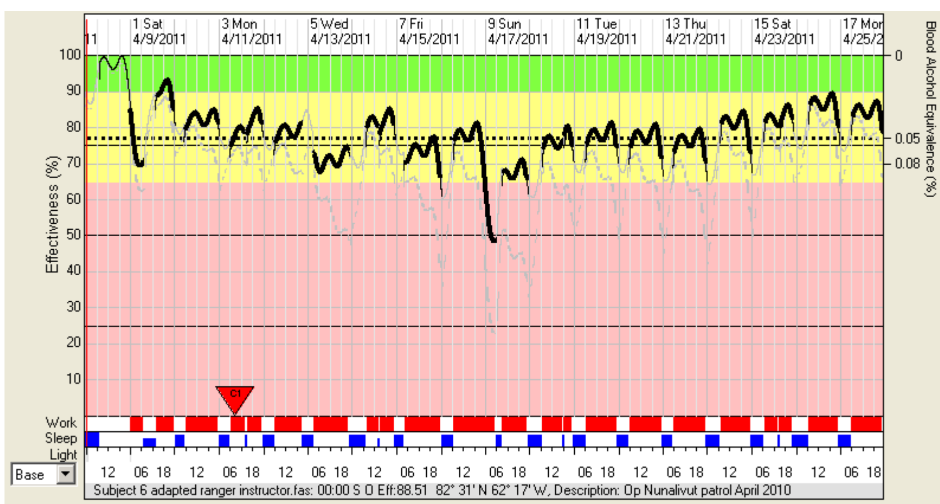

Figure 18: This Instructor (Subject 6) obtained an average of 6 hours and 6 minutes of sleep per day. His limited and irregular sleep reflects his role as a patrol leader who was responsible for ensuring a smoothly running patrol including communicating sitreps and receiving taskings by radio (from personal communications with this Instructor). He spent 100% of 3 days of work periods below criterion for a BAC level of 0.05% and reached equivalence to a BAC level of 0.08% on 4 days.

3.2.3 Model performance of each of the Freshly deployed soldiers

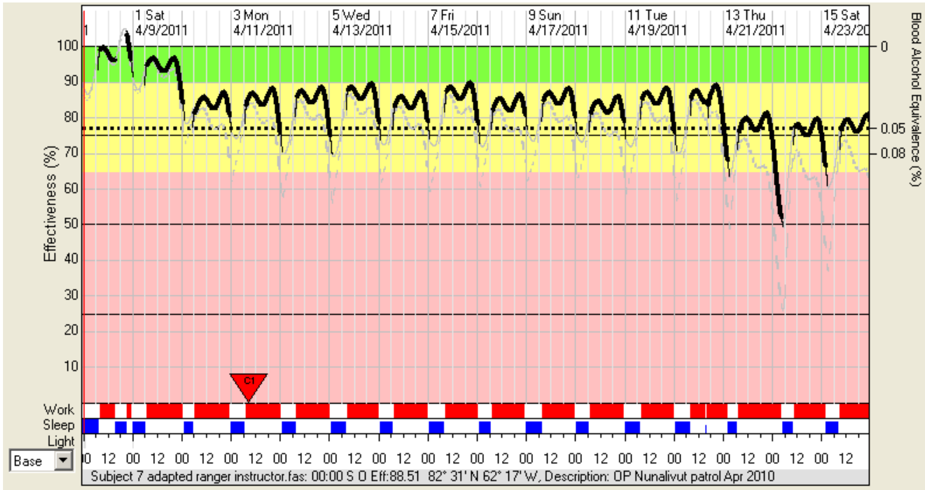

Figure 19: This freshly deployed soldier (Subject 7) obtained an average of 6 hours and 15 minutes of sleep per day. His mean cognitive effectiveness during work periods ranged from 75.4 % to 100 % and averaged 84.7%. His worst work period was split between April 21st (48% of the work period spent a performance levels below criterion for intoxication to a BAC of 0.05% and 3.5% of the time below BAC = 0.08%) and April 22nd (62.4% of the work period spent at performance levels below criterion for intoxication to a BAC level of 0.05% and 17% below criterion for BAC= 0.08%).

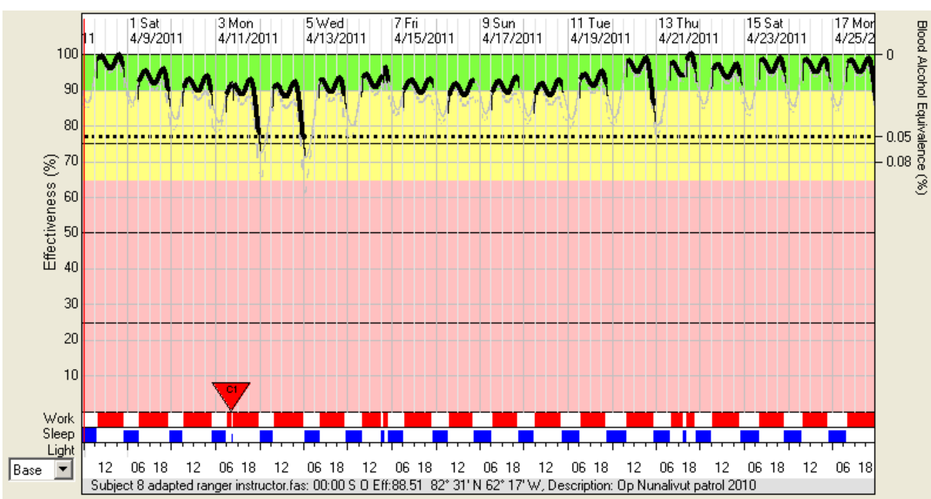

Figure 20: This freshly deployed soldier (Subject 8) obtained an average of 8 hours and 17 minutes of sleep per day. His mean cognitive effectiveness during work periods ranged from 89.2 % to 98.3 % and averaged 93.6%. He did not spend any significant time at performance levels equivalent to intoxicated levels of BAC.

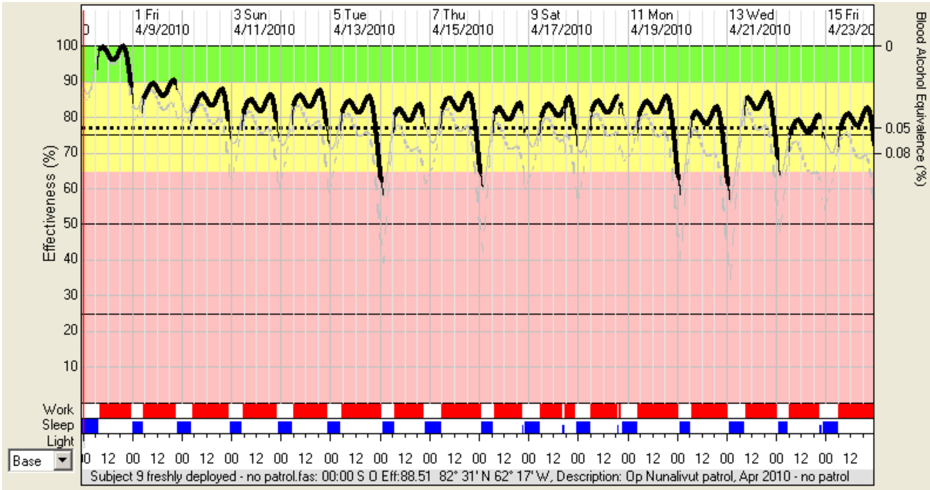

Figure 21: Subject 9 did not participate in a patrol and remained at CFS Alert for the duration of the exercise. He obtained an average of 6 hours and 1 minute of sleep per day. His mean cognitive effectiveness during work periods ranged from 78.0% to 97.7 and averaged 83.3%. He did not spend any significant time at performance levels equivalent to intoxicated levels of BAC. During 4 days, his performance attained 61% to 65% during which time he was performing as though he were intoxicated well beyond a BAC equivalent of 0.08%.

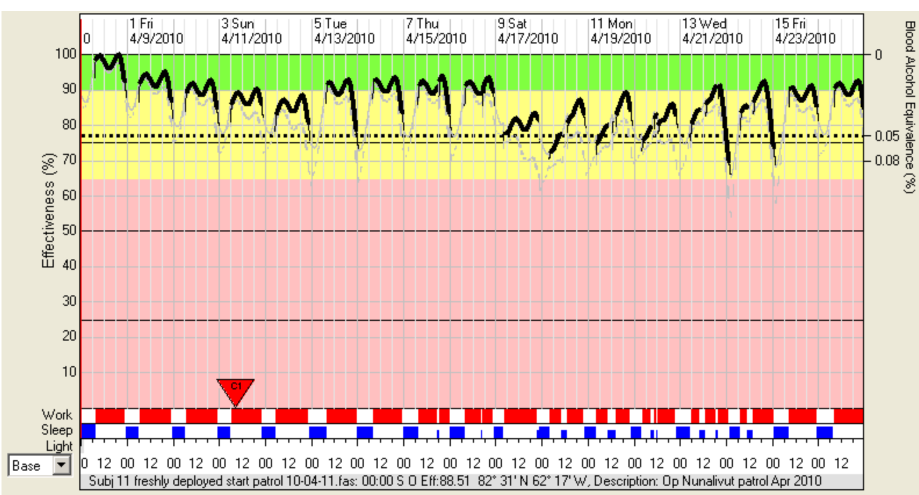

Figure 22: Subject 11 obtained an average of 7 hours and 8 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 75.1 % to 98.1 % and averaged 88.1 %. He had 4 work days where his cognitive effectiveness was equivalent to BAC of 0.05% or higher. On his worst day (April 18), 91.8% of his first work period of the day was spent at a BAC equivalent of 0.05% or higher.

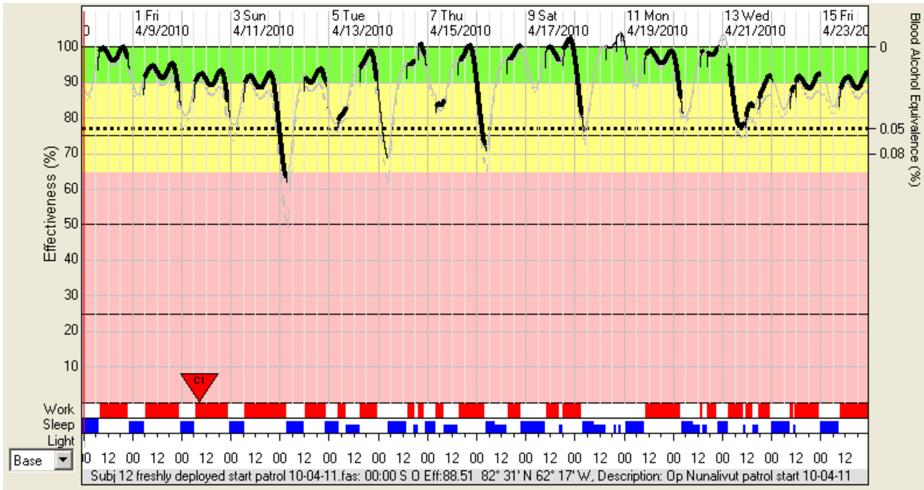

Figure 23: Subject 12 obtained an average of 9 hours and 8 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 82.7 % to 98.3 % and averaged 92.4 %. He had 2 work days where his cognitive effectiveness was equivalent to BAC of 0.05% or higher. On his worst day (April 11), 15.47% of his work period was spent at a BAC equivalent of 0.05% or higher and 8.3 % of that work period was spent at a BAC equivalent of 0.08% or higher.

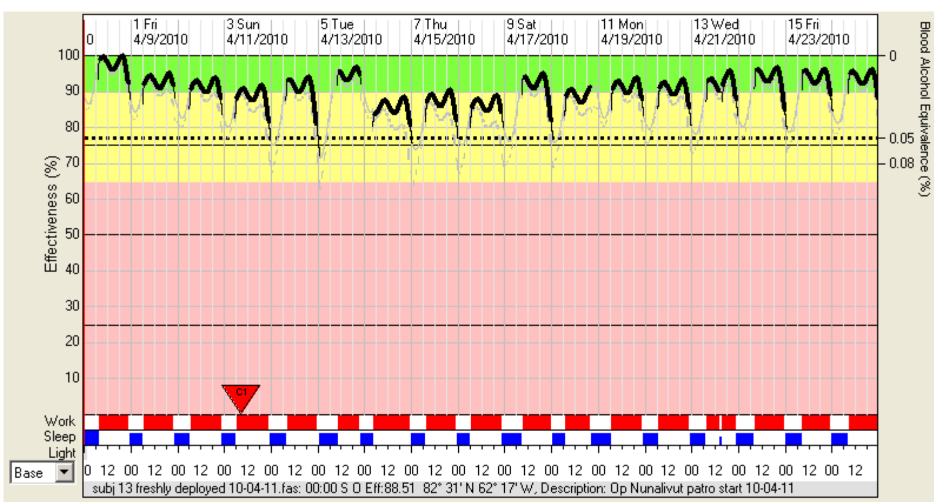

Figure 24: Subject 13 obtained an average of 7 hours and 31 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 86.0% to 98.1% and averaged 91.6%. None of his work periods involved performance equivalent to intoxicated levels of blood alcohol.

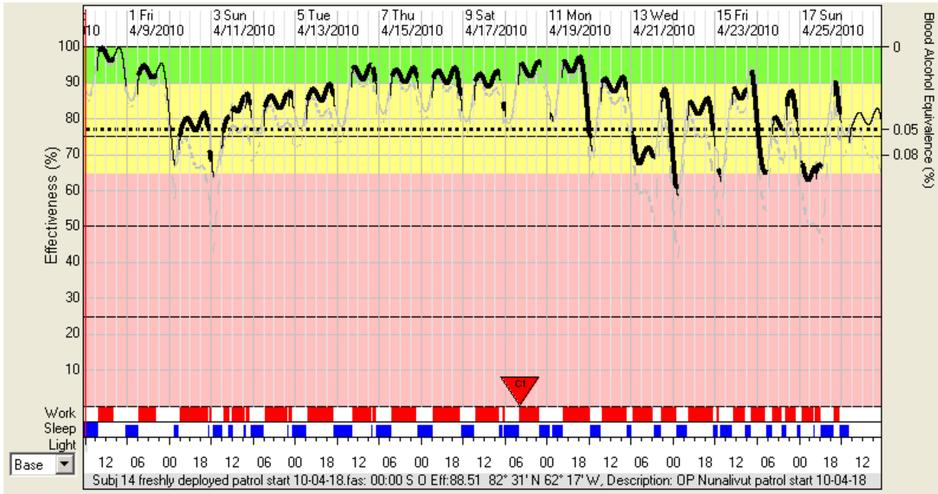

Figure 25: Subject 14 obtained an average of 7 hours and 7 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 65.3% to 98.0% and averaged 86.0%. He had 7 work periods where his performance was impaired equivalent to various BAC levels. One hundred percent of duration of the first work period of April 23rd and the first 2 work periods of April 25th were spent at performance equivalent to a BAC of 0.08 or higher.

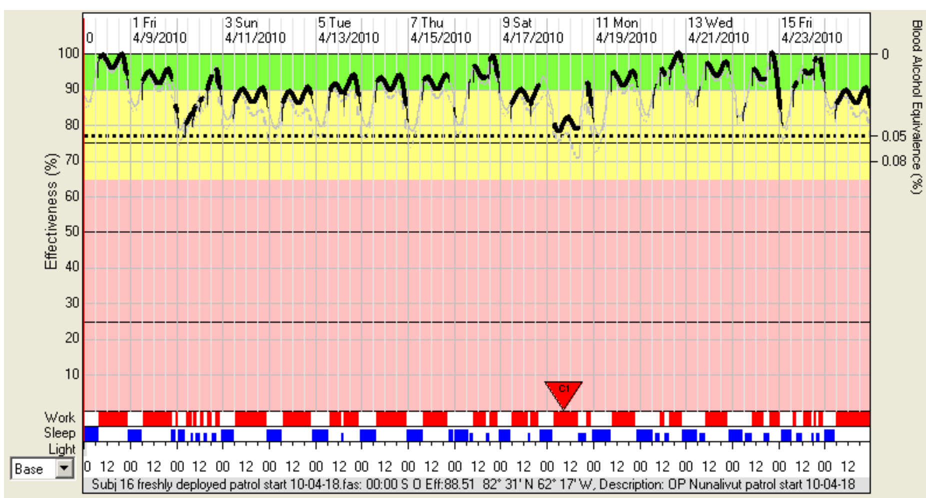

Figure 26: Subject 16 obtained an average of 8 hours and 29 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 79.4% to 98.2% and averaged 91.7%. His performance did not fall to levels equivalent to significant BAC levels. On his 3rd day at CFS Alert (April 10), he had multiple short sleep periods and therefore very broken sleep.

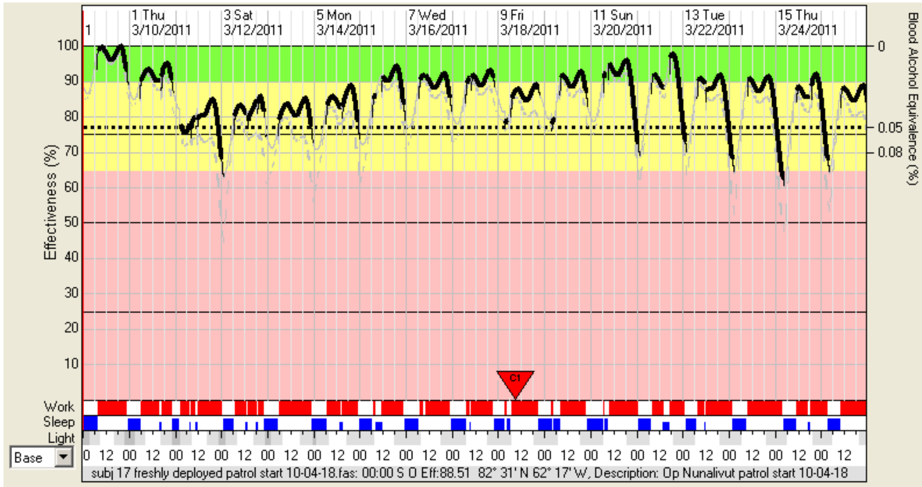

Figure 27: Subject 17 obtained an average of 7 hours and 4 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 76.3% to 98.2% and averaged 87.9%. He had 7 work periods where his performance fell to levels equivalent to a BAC of 0.05%. During 4 of those 7 work periods, his performance dropped to levels equivalent to a BAC of 0.08%. On his 3rd day at CFS Alert (April 10 - 11), this subject also had multiple short sleep periods and therefore very broken sleep.

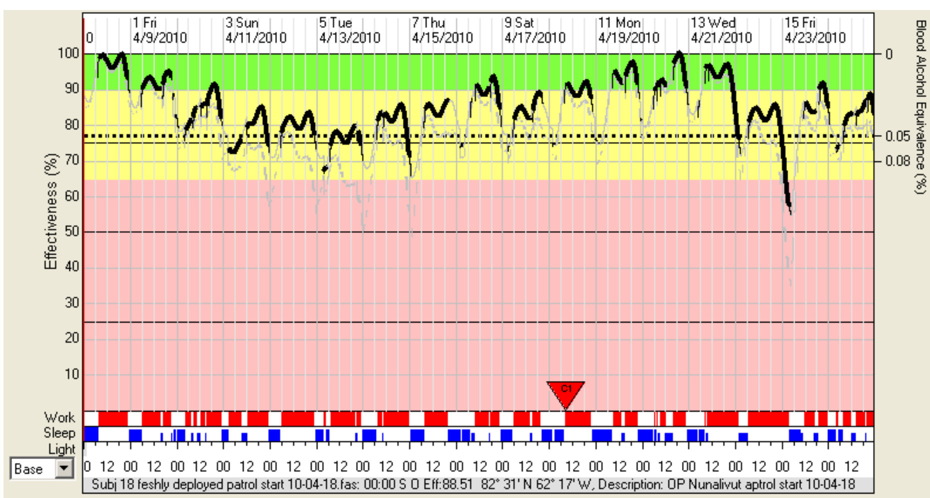

Figure 28: Subject 18 obtained an average of 7 hours and 17 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 73.8% to 98.2% and averaged 86.6%. He had 7 work periods where his performance fell to levels equivalent to BAC of 0.05%. During one of these work periods (April 22nd), his performance fell to 57% (beyond the limit of the BAC scale of FAST TM). At this level of performance, no one can perform well on any task. On his 3rd day at CFS Alert (April 10 - 11), this subject also had multiple short sleep periods and therefore very broken sleep.

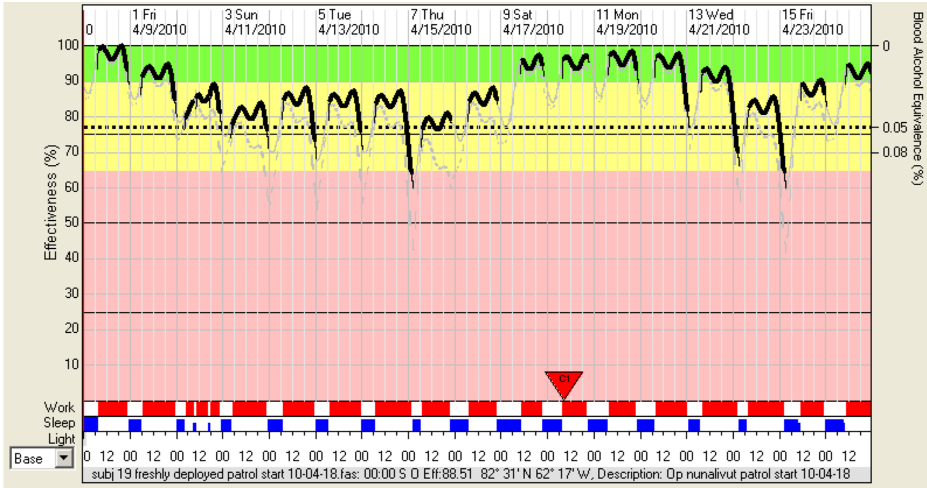

Figure 29: Subject 19 obtained an average of 7 hours and 17 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 78.7% to 98.2% and averaged 88.3%. He had 7 work periods where his performance fell to levels equivalent to a BAC of 0.05%. During two of these work periods (April 15th and 22nd), his performance fell to the pink zone of this graph (i.e., beyond the limit of the BAC scale of FAST TM). At this level of performance, no one can perform well on any task. This subject also shows evidence of broken sleep at CFS Alert on the night of April 10 - 11.

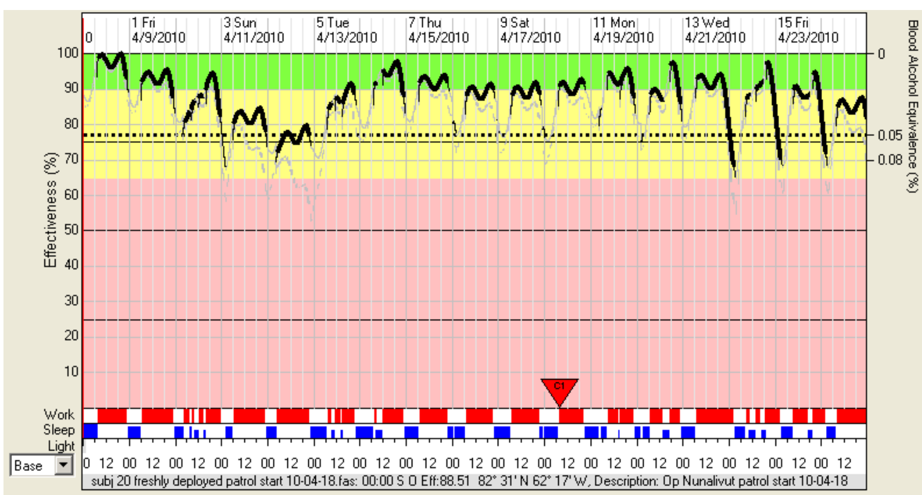

Figure 30: Subject 20 obtained an average of 7 hours and 27 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 76.7% to 98.2% and averaged 89.2%. He had 4 work periods where his performance fell to levels equivalent to a BAC of 0.05%. During the morning work period of April 22nd his performance fell to an equivalence of BAC of 0.08%. This subject also shows evidence of broken sleep at CFS Alert on the night of April 10 - 11.

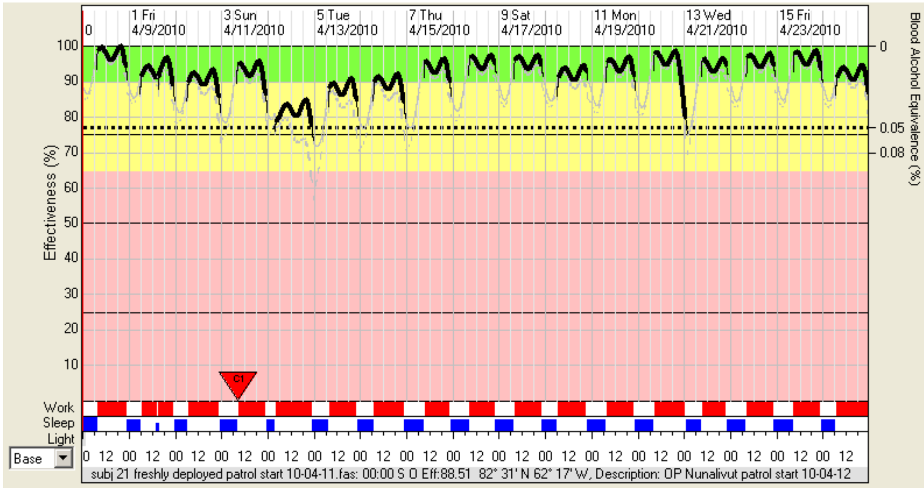

Figure 31: Subject 21 obtained an average of 7 hours and 53 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 82.2% to 98.2% and averaged 93.1%. None of his work periods were carried at performance levels associated with significant levels of BAC.

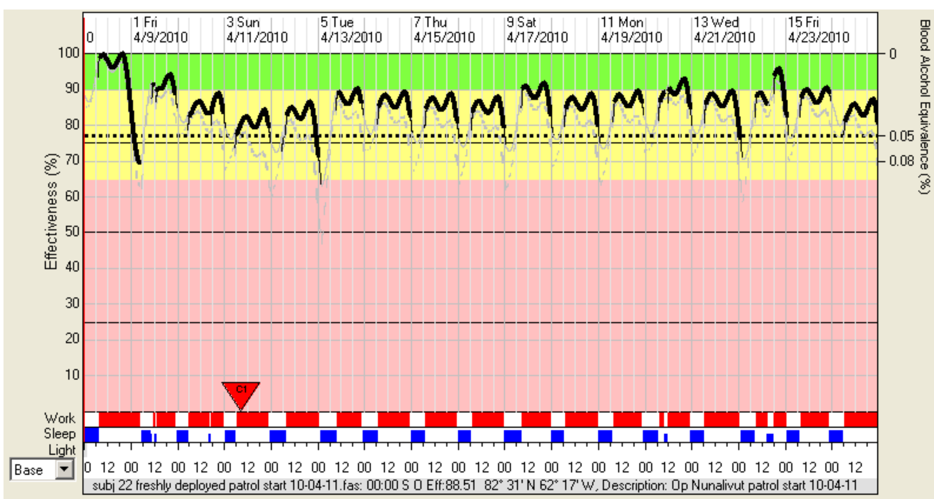

Figure 32: Subject 22 obtained an average of 6 hours and 47 minute3s of sleep per day. His mean cognitive effectiveness during work hours ranged from 79.3% to 92.7% and averaged 87.3%.He had 3 work periods (pre patrol on April 4th, and during patrol on each of April 12th, and April 21st) during which modeled performance reached levels equivalent to a BAC level of 0.05%.

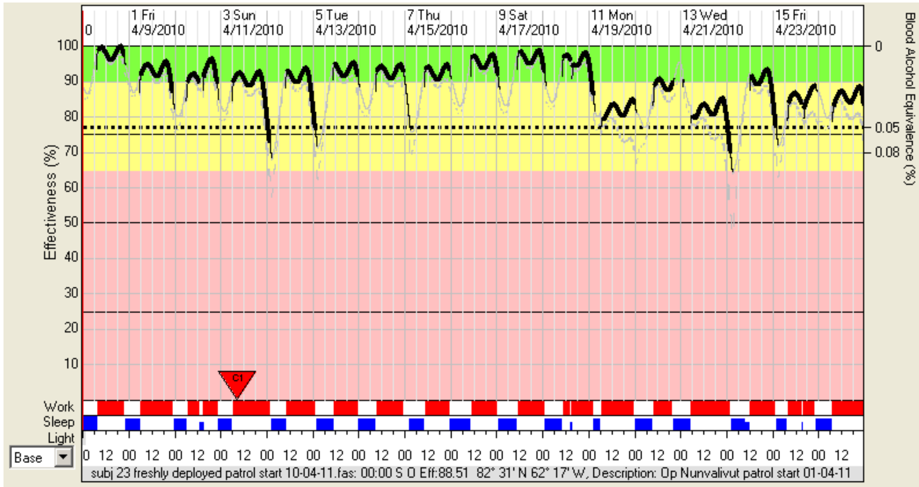

Figure 33: Subject 23 obtained an average of 7 hours and 35 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 81.7% to 98.4% and averaged 90.7%.He had a single work period on patrol (April 21st), during which modeled performance reached levels equivalent to a BAC of 0.05%.

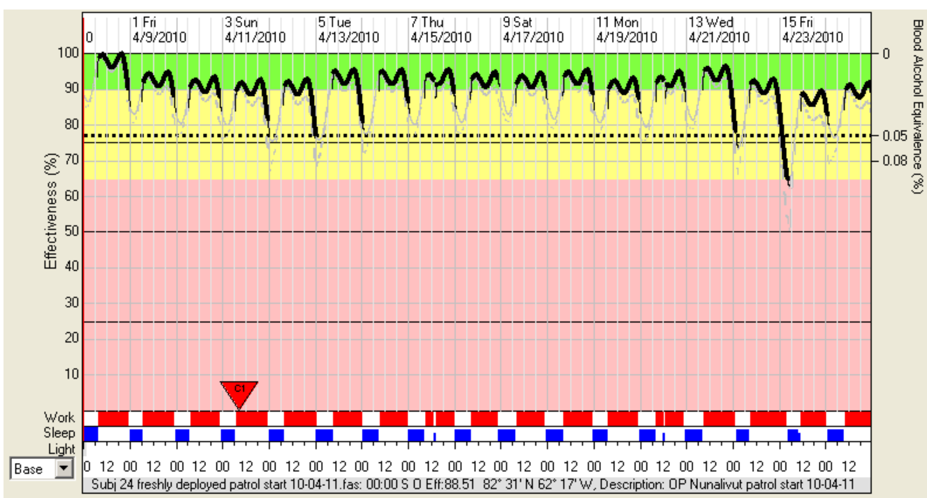

Figure 34: Subject 24 obtained an average of 7 hours and 23 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 87.3% to 97.8% and averaged 91.8%. He had a single period on patrol on April 22nd during which modeled performance reached levels equivalent to a BAC of 0.05%.

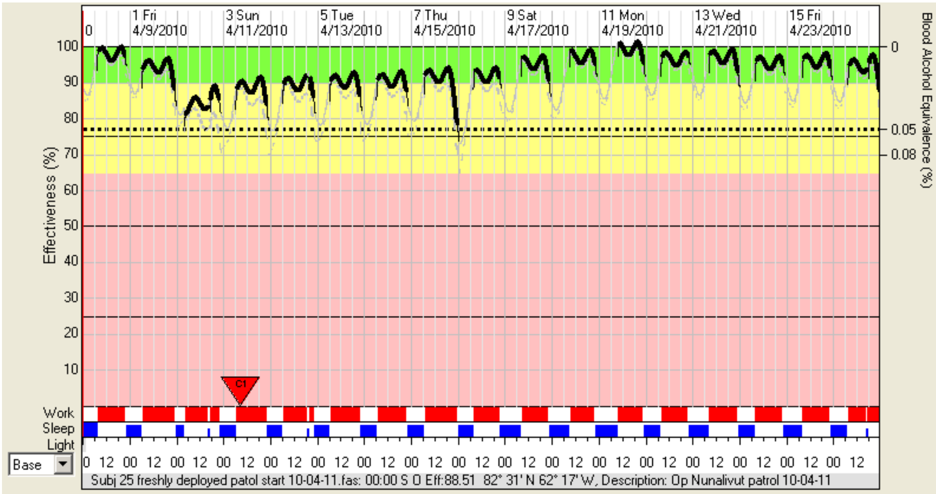

Figure 35: Subject 25 obtained an average of 8 hours and 7 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 88.1% to 98.4% and averaged 93.8%. None of his work periods involved modeled performance equivalent to significant BAC levels.

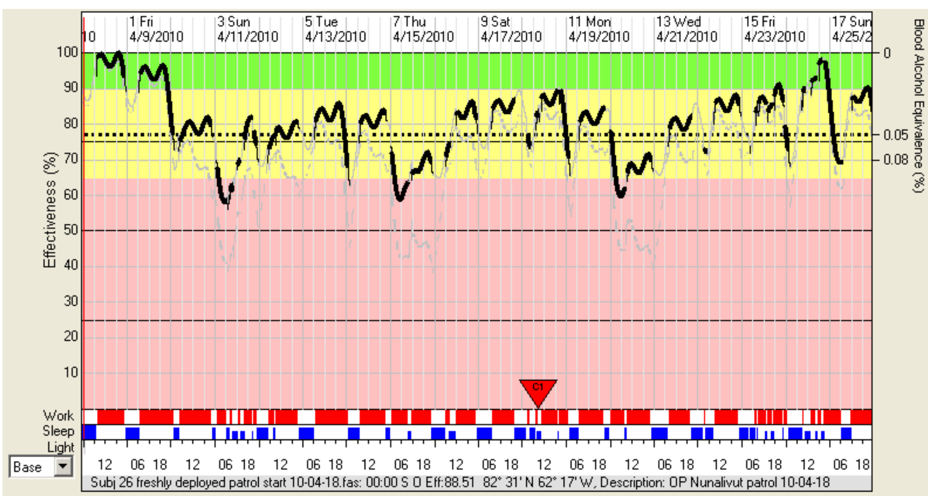

Figure 36: Subject 26 obtained an average of 6 hours and 56 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 62.3% to 98.2% and averaged 81.4%. On 3 occasions, his performance dropped into the pink zone reaching 58% to 60 % cognitive effectiveness where no one can perform well on any task. Of 37 total work periods, he spent 18 at a performance level equivalent to a BAC of 0.05% or higher and in 9 of those work periods his performance reached levels associated with a BAC of 0.08% and worse.

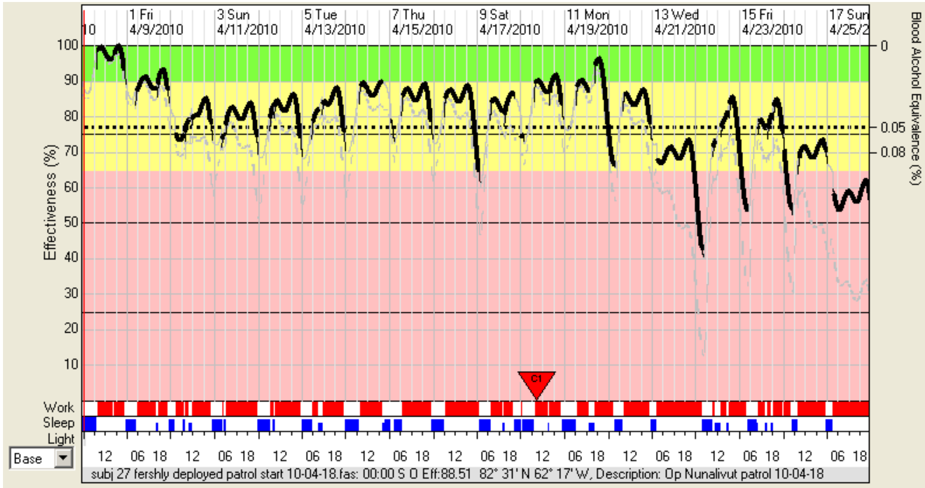

Figure 37: Subject 27 obtained an average of 6 hours and 6 minutes of sleep per day. His mean cognitive effectiveness during work hours ranged from 61.6% to 98.1% and averaged 80.3%. During patrol, on 4 occasions, his performance dropped into the pink zone reaching 43% to 57% cognitive effectiveness where no one can perform well on any task. Of 37 total work periods, he spent 18 at a performance equivalent to a BAC level of 0.05% or higher, and in 6 of those work periods, his performance reached levels associated with a BAC of 0.08% or worse.

4 Discussion

While there are some interesting data in this report, however, the fact that there are large differences in the numbers of subjects within each of the 3 groups (3 Rangers, 1 Instructor, and 19 freshly deployed soldiers) from various regions in the south of Canada (read below 60 degrees north latitude), precludes rigorous statistical analysis between groups of subjects.

Figures 1 to *7* illustrate the day-to-day changes in each of 7 sleep parameters (primary sleep minutes, total daily sleep minutes, number of daily naps, daily nap minutes, sleep latency, number of sleep episodes in the primary sleep period, and wake minutes after sleep onset). These sleep pattern parameters vary from day to day both pre-patrol and during patrol. Pre-patrol, most of these individuals slept on cots or air-mattresses in the gymnasium at CFS Alert. Such a sleep environment is less than ideal in terms of facilitating consistent and optimal sleep opportunity. During patrol, there were both static (deploy to one location and conduct daily patrols from the deployed location and return to that location each day) and roving patrols (continuously moving on a day to day basis), but we have no idea which of the freshly deployed troops participated in static patrols and which participated in roving patrols. Whether the patrols were static or roving, the sleep data suggest that there were day to day differences in Operational Tempo and therefore in sleep.

Figures 8 to *14* illustrate the average daily values for each of these seven sleep parameters. Averaging 16 days of data for each parameter provides a clearer picture of differences between groups. It appears that the Inuit Rangers obtain more sleep in their primary sleep periods than the freshly deployed troops. The Inuit Rangers nap less than freshly deployed troops, and have fewer sleep episodes in their primary sleep period than the freshly deployed troops, and they have fewer minutes of wake time within their primary sleep period than their freshly deployed counterparts. The fewer sleep episodes and relatively less waking minutes after sleep onset indicates a better quality of sleep for the Inuit Rangers relative to their freshly deployed counterparts. Relative to the 3 Inuit Rangers and the 19 freshly deployed soldiers, the single instructor who participated in this study had shorter primary sleep periods, fewer total daily sleep minutes, fewer daily nap minutes, a shorter sleep latency (indicating more fatigue/more sleep pressure), and more sleep episodes and waking minutes after sleep onset (indicating more fractured, less restful sleep). This instructor was a patrol leader and therefore responsible to ensure everyone functioned as per plan. This responsibility dictated waking up from time to time to inspect the individual tents/fire-watches and provide radio situation reports to Exercise headquarters in CFS Alert. It is evident that exercising this responsibility impacted on his ability to obtain sufficient sleep.

We anticipated that the Inuit Rangers would be better adapted to the Arctic than their counterparts from south of 60 degrees north latitude, and these data are consistent with that hypothesis. We wondered if Ranger Instructors who had been in the Arctic for at least a year might adapt or partially adapt to this environment. However, with only one Instructor participating in this study, this question remains unanswered.

With respect to modeled performance with FAST^{TM}, one Ranger (Subject 1) attained an average daily sleep of just under 8 hours and his work performance never reached levels equivalent to intoxication with a BAC level of 0.05%. Another Ranger (Subject 3) obtained an average of 10 minutes less sleep per day than Subject 1. His modeled performance dropped to a BAC

equivalence of 0.05% on 3 occasions and to a 0.08% BAC level on two occasions. The remaining Ranger (Subject 4) achieved an average of 1 hour less daily sleep than Subject 3 and had four work periods where his modeled performance reached levels associated with a BAC level of 0.05% but did not reach the equivalence to a BAC of 0.08%.

The Instructor only attained an average daily sleep of just over 6 hours due to exercising his responsibility as a patrol leader. This limited amount of sleep resulted in 100% of 3 work periods being spent at a 0.05% BAC equivalence. He also briefly attained equivalence to a BAC level of 0.08% on four occasions.

Of the 19 freshly deployed soldiers, 4 (Subjects 8, 13, 16, and 21) had sufficient sleep to avoid impacted performance equivalent to intoxicated levels of BAC. The average daily sleep of these 4 individuals ranged from 7 hours and 31 minutes to 8 hours and 29 minutes. Of the 19 freshly deployed troops, 17 reached levels of performance equivalent to a BAC of 0.05%, 16 attained performance associated with a BAC of 0.08%, and 11 dropped well beyond a BAC of 0.08% and reached the "pink" zone of the FAST^{TM} model graphs (i.e., less than 65% cognitive effectiveness which is a level of performance where no one can function well on any task). While Subject 12 had an average daily sleep of 9 hours and 8 minutes, on several occasions during his patrol, he had limited sleep and attained levels of performance equivalent to BAC levels of 0.05%, 0.08% and beyond to the "pink" zone (i.e., less than 65% cognitive effectiveness). Essentially, in spite of very adequate average daily sleep, on several occasions, he was not immune to the debilitating effects of limited sleep.

5 Conclusions

All Arctic patrollers require sufficient sleep to avoid impaired performance. In some, cases the Operational Tempo of Arctic work may preclude sufficient sleep. Planners who set the Operational Tempo should understand the impact that insufficient sleep can have on operational readiness, and plan accordingly, to the extent possible.

DRDC Toronto Technical Report TR 2010-056 “General Recommendations on Fatigue Risk Management for the Canadian Forces” includes specific information on the management of fatigue. While it is directed primarily towards an aviation environment, many of the general recommendations are equally applicable to a land force environment and could provide useful guidance to planners and commanders in the management of fatigue.

Given the very limited number of Arctic exercises, it is very desirable that defence researchers have an opportunity to participate in the planning stages of Arctic operations to maximize the benefits available from limited Arctic troop deployments.

References

[1] Paul, M. A., Gray, G. W., Lieberman, H. R., Love, R. J., Miller, J. C., and Arendt, J. (2010). Management of circadian desynchrony (jetlag and shiftlag) in cf air operations. TR 2010-002, DRDC Toronto.

[2] Paul, M. A., Gray, G. W., and Miller, J. C. (2007). Fighter pilot cognitive effectiveness during exercise wolf safari. (TR 2007-020). TR 2007-020. DRDC Toronto.

[3] Paul, M. A., Gray, G. W., and Miller, J. C. (2007). Cognitive effectiveness of cf-18 instructor pilots during routine training. (TR 2007-028). TR 2007-028. DRDC Toronto.

[4] Paul, M. A., Gray, G. W., Nesthus, T. E., and Miller, J. C. (2008). An assessment of the cf submarine watch schedule variants for impact on modeled crew performance. TR 2008-007, DRDC Toronto.

[5] Paul, M. A., Hursh, S. R., and Miller, J. C. (2010). Alternative submarine watch schedules: *Recommendations for a new cf watch schedule*. TR 2010-001, DRDC Toronto.

[6] Paul, M. A. and Miller, J. C. (2004). Fatigue assessment in camp mirage cc130 aircrew: Recommendations for pharmacologic intervention. (TR 2004-021). TR 2004-021. DRDC Toronto.

[7] Paul, M. A. and Miller, J. C. (2005). Consideration of 5 canadian forces fire-fighter shift schedules. (TR 2005-027).

[8] Arnedt, J. T., Wilde, G. J. S., Munt, P. W., and MacLean, A. W. (2001). How do prolonged wakefulness and alcohol compare in the decrements they produce on a simulated driving task? *Accident Analylsis and Prevention*, 33, 337-344.

[9] Dawson, D. and Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature*, 388, 235.

[10] Lamond, N. and Dawson, D. (1999). Quantifying the performance impairment associated with fatigue. *Journal of Sleep Research*, 8 (no. 4), 255-262.

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Annex A Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) Model

A.1 Fatigue Avoidance Scheduling Tool (*FAST*™)

The Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) model integrates quantitative information about (1) circadian rhythms in metabolic rate, (2) cognitive performance recovery rates associated with sleep, and cognitive performance decay rates associated with wakefulness, and (3) cognitive performance effects associated with sleep inertia to produce a 3-process model of human cognitive effectiveness.

The SAFTE model has been under development by Dr. Steven Hursh for more than a decade. Dr. Hursh, formerly a research scientist with the US Army, is employed by SAIC (Science Applications International Corporation) and Johns Hopkins University and is currently under contract to the WFC (Warfighter Fatigue Countermeasures) R&D Group and NTI, Inc. to modify and expand the model.

The general architecture of the SAFTE model is shown in Figure 1. A circadian process influences both cognitive effectiveness and sleep regulation. Sleep regulation is dependent upon hours of sleep, hours of wakefulness, current sleep debt, the circadian process and sleep fragmentation (awakenings during a sleep period). Cognitive effectiveness is dependent upon the current balance of the sleep regulation process, the circadian process, and sleep inertia.

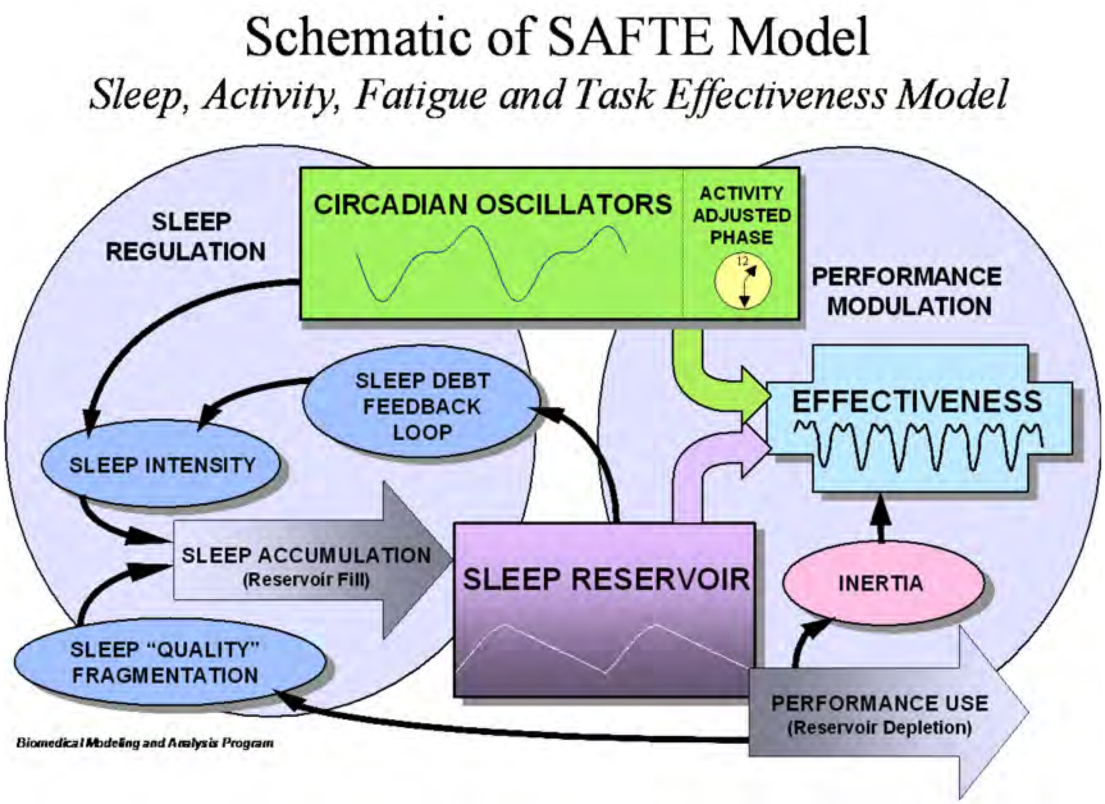


Figure 1. Schematic of SAFTE Model

SAFTE has been validated against group mean data from a Canadian laboratory that were not used in the model's development (Hursh et al., in review). Additional laboratory and field validation studies are underway and the model has begun the USAF Verification, Validation and Accreditation (VV&A) process.

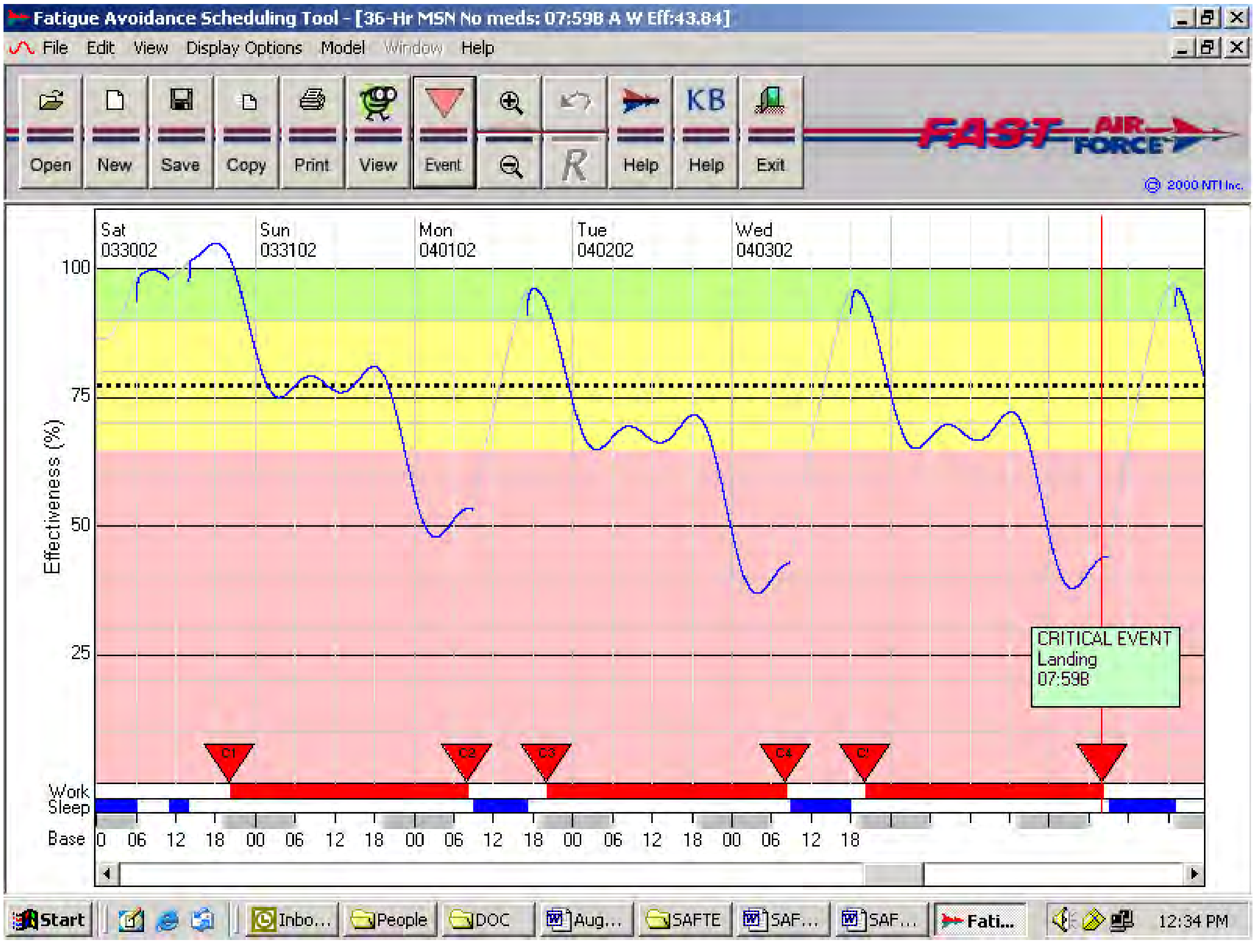
The model does not incorporate the effects of pharmacological alertness aids; chronic fatigue (motivational exhaustion); chronic fatigue syndrome; fatiguing physiological factors such as exercise, hypoxia or acceleration; sleep disorders; or the fatiguing effects of infection.

The SAFTE Model has a number of essential features that distinguish it from other attempts to model sleep and fatigue (Table D-1). Together, these features of the model allow it to make very accurate predictions of performance under a variety of work schedules and levels of sleep deprivation.

Table A-1. SAFTE model essential features.

KEY FEATURES	ADVANTAGES
Model is homeostatic. Gradual decreases in sleep debt decrease sleep intensity. Progressive increases in sleep debt produced by extended periods of less than optimal levels of sleep lead to increased sleep intensity.	Predicts the normal decline in sleep intensity during the sleep period. Predicts the normal equilibrium of performance under less than optimal schedules of sleep.
Model delays sleep accumulation at the start of each sleep period.	Predicts the detrimental effects of sleep fragmentation and multiple interruptions in sleep.
Model incorporates a multi-oscillator circadian process.	Predicts the asymmetrical cycle of performance around the clock.
Circadian process and Sleep-Wake Cycle are additive to predict variations in performance.	Predicts the mid-afternoon dip in performance, as well as the more predominant nadir in performance that occurs in the early morning.
Model modulates the intensity of sleep according to the time of day.	Predicts circadian variations in sleep quality. Predicts limits on performance under schedules that arrange daytime sleep.
Model includes a factor to account for the initial lag in performance upon awakening.	Predicts sleep inertia that is proportional to sleep debt.
Model incorporates adjustment to new time zones or shift schedules	Predicts temporary “jet-lag” effects and adjustment to shift work

The Fatigue Avoidance Scheduling Tool (*FAST*™) is based upon the SAFTE model. *FAST*™, developed by NTI, Inc. as an AF SBIR (Air Force, Small Business Innovative Research) product, is a Windows® program that allows planners and schedulers to estimate the average effects of various schedules on human performance. It allows work and sleep data entry in graphic and text formats. A work schedule comprised of three 36-hr missions each separated by 12 hours is shown as red bands on the time line across the bottom of the graphic presentation format in Figure 2. Average performance effectiveness for work periods may be extracted and printed as shown in the table below the figure.



AWAKE			WORK		
Start Day - Hr	Duration (Minutes)	Mean Effectiveness	Start Day - Hr	Duration (Minutes)	Mean Effectiveness
0 - 06:00	300	98.97	0 - 20:00	1079	81.14
0 - 14:00	2580	76.42	1 - 14:00	1080	63.97
2 - 17:00	2400	64.78	2 - 20:00	1079	71.23
4 - 18:00	2340	64.58	3 - 14:00	1080	54.51
6 - 19:00	1741	72.23	4 - 20:00	1079	72.00
			5 - 14:00	1080	54.92

Figure 2: Sample FAST^{tm} display. The triangles represent waypoint changes that control the amount of light available at awakening and during various phases of the circadian rhythm. The table shows the mission split into two work intervals, first half and second half.

Sleep periods are shown as blue bands across the time line, below the red bands.

The vertical axis of the diagram represents composite human performance on a number of associated cognitive tasks. The axis is scaled from zero to 100%. The oscillating line in the diagram represents expected group average performance on these tasks as determined by time of day, biological rhythms, time spent awake, and amount of sleep. We would expect the predicted performance of half of the people in a group to fall below this line.

The green area on the chart ends at the time for normal sleep, ~90% effectiveness.

The yellow indicates caution.

The area from the dotted line to the red area represents performance level during the nadir and during a 2nd day without sleep.

The red area represents performance effectiveness after 2 days and a night of sleep deprivation.

The expected level of performance effectiveness is based upon the detailed analysis of data from participants engaged in the performance of cognitive tasks during several sleep deprivation studies conducted by the Army, Air Force and Canadian researchers. The algorithm that creates the predictions has been under development for two decades and represents the most advanced information available at this time.

References

[1] Eddy DR, Hursh SR (2001). *Fatigue Avoidance Scheduling Tool (FAST).* AFRL-HE-BR-TR-2001-0140, SBIR Phase I Final Report, Human Effectiveness Directorate Biodynamics and Protection Division, Flight Motion Effects Branch, Brooks AFB TX 78235-5105.

[2] Hursh SR, Redmond DP, Johnson ML, Thorne DR, Belenky G, Balkin TJ, Storm WF, Miller JC, Eddy DR. (2003). Fatigue models for applied research in warfighting. Supplement to *Aviation, Space and Environmental Medicine*, in review.

[3] Hursh SR (1998). *Modeling Sleep and Performance within the Integrated Unit Simulation System (IUSS).* Technical Report Natick/TR-98/026L. Science and Technology Directorate, Natick Research, Development and Engineering Center, United States Army Soldier Systems Command, Natick, Massachusetts 01760-5020.

[4] Hursh SR, Redmond DP, Johnson ML, Thorne DR, Belenky G, Balkin TJ, Miller JC, Eddy DR, Storm WF (2003). The DOD Sleep, Activity, Fatigue and Task Effectiveness Model. *Proceedings of the 12th Conference on Behavior Representation in Modeling and Simulation (BRIMS 2003)*, 03-BRIMS-001, 14-15 May 2003, Mesa, Arizona.

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List of symbols

BAC	Blood Alcohol Content
CF	Canadian Force
CFS	Canadian Forces Station
FAST™	Fatigue Avoidance Scheduling Tool
DND	Department of National Defence
DRDC	Defence Research & Development Canada
HMCS	Her Majesty Canadian Ship
Op	Operation
SAR Techs	Search and Rescue Technicians
WASO	Wake After Sleep Onset

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(U) Background: The goal of this work was to monitor sleep (via wrist actigraphs) in Arctic Patrollers and generate cognitive effectiveness models for each patroller using a program called Fatigue Avoidance Scheduling Tool (FASTTM). Methods: Actigraphic data were collected from 23 Arctic patrollers of whom 3 were Inuit Rangers (who ranged from 25 to 62 years of age), from one ranger instructor (48 years of age) and from 19 troops who were freshly deployed from various regions across southern Canada (who ranged from 21 to 54 years of age). The patrols ranged from 5 to 14 days in duration. Sleep data were recorded for several days at Canadian Forces Station Alert prior to departing on patrol and throughout the patrols. The following sleep parameters (primary sleep period minutes, total daily sleep minutes, number of daily naps, daily nap minutes, sleep latency in minutes, number of sleep episodes in the primary sleep period, and WASO (Wake After Sleep Onset) in minutes) were recorded and graphed for each day as well as averaged over 16 days. Total daily sleep minutes along with daily work periods were inputted to FASTTM to generate models of cognitive effectiveness for each of the 23 Arctic patrollers. Results and Discussion: Inuit Rangers obtained more sleep in their primary sleep periods, have fewer sleep episodes and have less wake time within their primary sleep periods than their freshly deployed counterparts. On several days the FASTTM models for 2 of the 3 Inuit Rangers predicted levels of performance equivalent to a blood alcohol content of 0.05%. The FASTTM models for 14 freshly deployed soldiers predicted more work periods spent at 0.05% and at 0.08% blood alcohol content than their Inuit Ranger counterparts. Conclusions: All Arctic patrollers require sufficient sleep to avoid impaired performance. Planners who set the Operational Tempo for Arctic exercises should understand the impact that insufficient sleep can have on operational readiness, and plan accordingly, to the extent possible.

(U) Contexte : Les présents travaux visaient à surveiller le sommeil (à l'aide de bracelets actigraphes) chez des patrouilleurs de l'Arctique et à produire des modèles de l'efficacité cognitive pour chaque patrouilleur en utilisant un programme appelé Fatigue Avoidance Scheduling Tool (FASTTM). Méthodes : Les données actigraphiques de 23 patrouilleurs de l'Arctique, qui comprenaient 3 Rangers inuits (âgés de 25 à 62 ans), un instructeur ranger (âgé de 48 ans) et 19 soldats (âgés de 21 à 54 ans) nouvellement déployés depuis diverses régions dans le sud du Canada, ont été recueillies. Les patrouilles se sont échelonnées sur une période 5 à 14 jours. Les données sur le sommeil ont été consignées pendant plusieurs jours à la station des Forces canadiennes Alerte avant le départ pour la patrouille et pendant les patrouilles. Les paramètres suivants sur le sommeil ont été consignés et reproduits sous forme de graphiques pour chaque journée, et les moyennes ont été établies sur 16 jours : principales périodes de sommeil en minutes, durée totale du sommeil quotidien en minutes, nombre de siestes quotidiennes, durée des siestes quotidiennes en minutes, latence du sommeil en minutes, nombre d'épisodes de sommeil dans la principale période de sommeil et temps d'éveil en minutes. La durée totale de sommeil quotidien en minutes ainsi que les périodes de travail quotidiennes ont été saisies dans le logiciel FASTTM afin de produire des modèles de l'efficacité cognitive pour chacun des 23 patrouilleurs de l'Arctique. Résultats et analyses : Les Rangers inuits ont dormi davantage dans leurs principales périodes de sommeil, ils avaient moins d'épisodes de sommeil et un temps d'éveil moindre dans leurs principales périodes de sommeil que leurs vis à vis nouvellement déployés. Sur plusieurs jours, les modèles FASTTM pour 2 des 3 Rangers inuits prédisent des niveaux de rendement équivalent à un

taux d'alcoolémie de 0,05 %. Les modèles FASTTM pour 14 soldats nouvellement déployés prédisent davantage de périodes de travail effectuées avec un taux d'alcoolémie de 0,05 % et de 0,08 % que leurs vis à vis Rangers inuits. Conclusions : Tous les patrouilleurs de l'Arctique doivent dormir suffisamment pour éviter une baisse de rendement. Les planificateurs qui établissent le rythme opérationnel pour les exercices dans l'Arctique doivent comprendre les répercussions du manque de sommeil sur l'état de préparation opérationnelle et planifier en conséquence, dans la mesure du possible.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) sleep hygiene
modeled performance
Arctic patrollers

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